4—A Critical Review of the Lower Palaeozoic Succession of Tasmania

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Abstract

The literature dealing with the Lower Palaeozoic rocks of Tasmania is reviewed, and attention is drawn to the changing ideas of the correlation of these rocks and the reasons for these changes. It is pointed out that until detailed fossil collections are examined by modern palaeontological methods, the true sequences cannot be determined, or the structural problems fully appreciated. It is suggested that the Cambrian follows the Proterozoic probably conformably, that the Ordovician is separted from the Cambrian by a diastrophic period, and the same applies to the Silurian and Ordovician, although in this case the age of the basal beds of the Silurian, the West Coast Range Conglomerates, has not been determined. There is a conformable passage to the Lower Devonian, which corresponds to the Victorian Yeringian.

Introduction

During my short term as Government Geologist for Tasmania, much thought was devoted to the Lower Palaeozoic Succession, as the metalliferous deposits are confined to these rocks. It soon became evident that the ideas as to the sequence had changed so often that the evidence that gave rise to these changes had to be assessed. It was intended to study some of these problems in the field, but owing to my return to Victoria this was not possible. These notes are intended as a summary of the scattered literature on this problem, to draw attention to some of the problems yet to be solved, to the need for fresh evidence, and its study by modern palaeontological and stratigraphical methods.

Historical

Three main periods may be considered:

(i) *First Period, from* 1860-1910. This embraces that period when field work was actively supported by identification of the fossils during these surveys. Thus Gould sent fossils to Salter and McCoy;

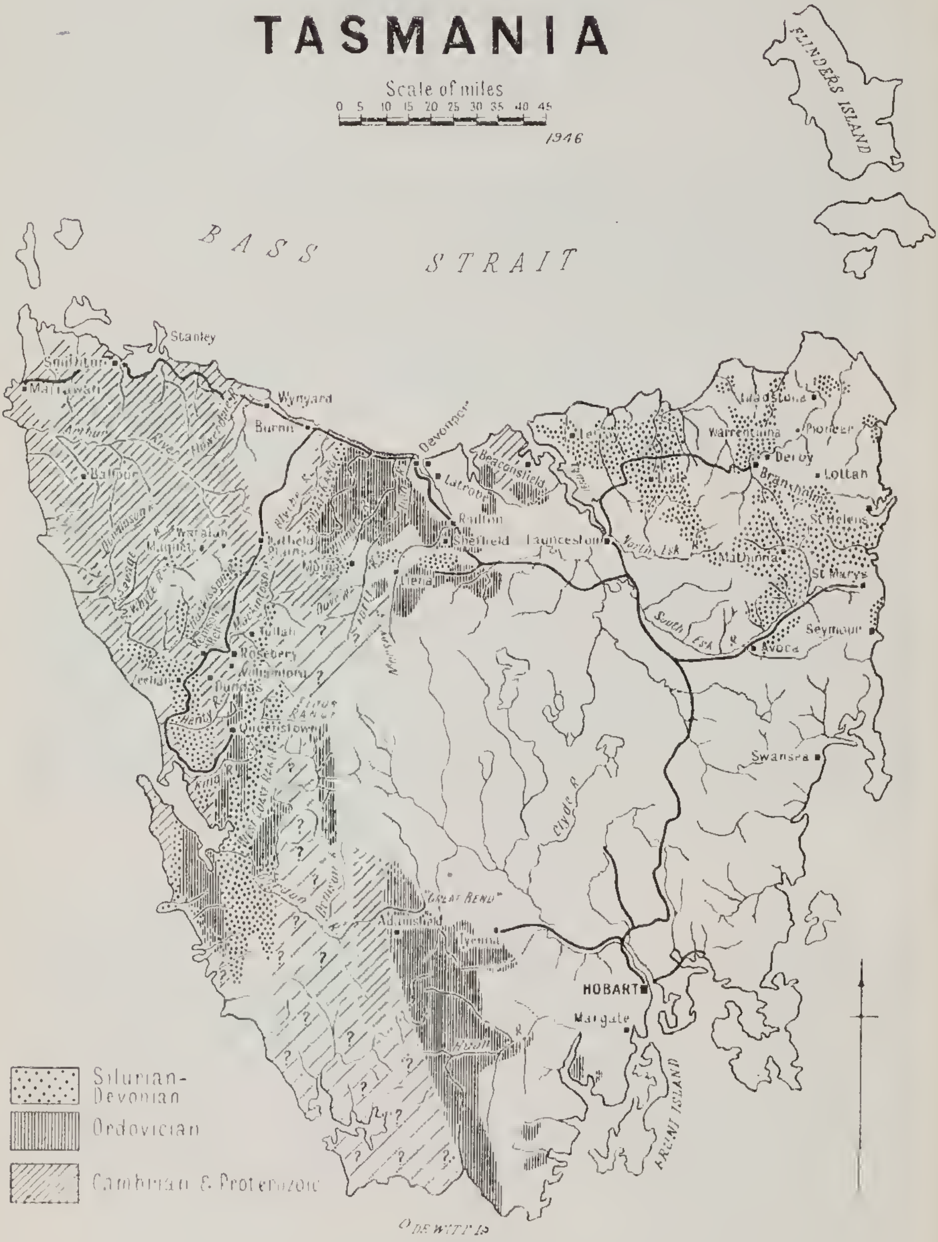
TASMANIA
Scale of miles
0 5 10 15 20 25 30 35 40 45
1946
FLINDERS ISLAND
BASS STRAIT
Stanley
Wynyard
Burnie
Devonport
Latrobe
Beaconsfield
Railton
Sheffield
Launceston
Gladstone
Warrentinna
Pioneer
Derby
Lottah
St Helens
Mathinna
St Marys
Seymour
Avoca
Swansea
Waratah
Balfour
Rosebery
Dundas
Queenstown
Tullah
Zeehan
Adamsfield
HOBART
Margate
Clyde R.
South Esk R.
North Esk R.
BRUNI ISLAND
"GREAT BEND"
Silurian-Devonian
Ordovician
Cambrian & Proterozoic

Fig 1.

CORRELATION TABLE

	Gould 1860–1870	R. Etheridge & T. Stevens 1882	Johnston 1888	Twelvetrees 1909	Twelvetrees & Ward 1910	P.B. Nye & A.N. Lewis 1928	Sir Edgeworth David 1932	Nye & Blake 1938	A.N. Lewis 1940	Dr D. Hill 1942	Thomas 1946
DEVONIAN TO SILURIAN	Eldon Beds Caroline Ck Sandstones Don-Chudleigh limestones Caroline Creek limestones. Gordon River limestone	North West Coast conglomerates	Fingal slates Eldon Valley beds Eldon Group: Dial Range and North West Coast conglomerates.	Eldon Valley clay slates etc. Fossiliferous limestones, sandstones and slates at Zeehan, Heazlewood, Queen and Nelson River etc.	8 Pale slates & sandstones 7 Sandstones, pebbly grits etc. 6 Limestone	Middle Silurian: Queen River slates & sandstones. Gordon River limestones. Tubicolar sandstones.	Melbournian – Yeringian: Zeehan sandstone etc – Gordon River limestones Despatch limestone Limestone of Lyell & Zeehan Tubicolar sandstone.	6 Queen River slate & sandstone series 5 Gordon River limestone series 4 Discoidal series 3 Quartzite series 2 Pine stem or Tubicolar series		Lower Devonian: Pleurodictyum megastomum shales, Zeehan. Ludlovian: Point Hibbs limestone	Eldon Group: Queen River series; Mathinna slates. (of North East) Gordon R. Group: Gordon River limestones. Tubicolar sandstone
Upper Silurian of Early Authors	West Coast Range conglomerates		Queen River formation		5 Shale and slate.	West Coast Range conglomerate series.	West Coast Range conglomerates etc.	1 West Coast Range conglomerate series.		Wenlockian: Limestone on Gordon River. Valentian: Limestone at Liena & Head of Nelson River.	West Coast Range conglomerate series.
											Unconformity
ORDOVICIAN Lower Silurian of Early Authors			2 Gordon River Group: Fossiliferous limestones, slates, grits & conglomerates at Point Hibbs, Franklin River & Florentine Valley 1 Auriferous Slate Group: Auriferous felspar porphyries etc. of Lymington, slates of Beaconsfield, Lefroy, Mathinna etc.	Slate and sandstone in goldfields of Lefroy Mathinna etc. Limestones of Gordon, Florentine, Railton, Mole Ck., Beaconsfield etc.	4 ? Ordovician: Sandstones & slates of Nubeena Hills. 3 Cambro-Ordovician: Tuffs, breccias, spilitic, lavas, etc.	Cambro-Ordovician: Diastrophic period. a Porphyroid complex & Mathinna slates. b Read Rosebery schists. c Dundas slates. d Mathinna slates. e Balfour slates etc.	Dundas series. Limestones of Blenkhorn's Quarry etc. Cambro-Ordovician: Dundas slates (possibly Middle Cambrian)	Cambro-Ordovician: Diastrophic period. Dundas slate series Balfour series (? Sil) Mathinna slates (? Sil.) Rosebery series. Sisters Hill series Farrell slates.	Junee Series: 3 Junee limestone; 2 Fossiliferous mudstones etc.; 1 Conglomerates, breccias, quartzites etc.	Upper Ordovician or ? Silurian: Queenstown limestone. Smelter's Road limestone. Note – Arrows indicate possible range.	Diastrophic Period ? King River series Junee Series: Limestones (Junee, Melrose, Railton, Chudleigh etc., ? Beaconsfield etc. Caroline Creek sandstones. "Magog" conglomerates.
											Unconformity
CAMBRIAN		Caroline Creek Beds.	3 Primordial Calciferous Group: Limestones of Chudleigh 2 Magog Group: Sandstones etc of Chudleigh Magog Range etc. 1 Dikelocephalus Group: Caroline Creek grits etc.	Incertae sedis: Dundas slates, Leven slates, Mt. Lyell porphyries etc. Dikelocephalus sandstones at Caroline Ck Discoidal sandstone Loddon River etc. Tubicolar sandstone, Middlesex etc. Conglomerates of West Coast Range.	2 Tubicolar sandstone. 1 West Coast Range conglomerate series.	(a) Dikelocephalus sandstones of Caroline Creek (b) Diketocephalus sandstones of Florentine. (c) Slates of Hatfield Plains etc.	Upper (Tremadocian): Caroline Creek series.	4 Caroline Creek sandstone series. 3 Florentine Valley slate series. 2 Hatfield Plains series. 1 Arthur River slate series.	Unconformity Dundas series.		Dundas Series (including): ? Bischoff, Balfour slates. Rosebery Series. Farrell slates. Arthur River and Hatfield Plains. ? Stage: Grey green quartzite; White quartzite stage. (of Smithton)


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foundation of an error which led to subsequent confusion. He states that after his work in the Mersey Valley he regarded the Don limestones as low in the palaeozoic succession, but after a visit to the Great Bend of the Gordon and the Florentine Valley he considered the limestones occurring there as identical with those of the Don Valley (in this he was quite correct), but as the fossil evidence yielded by the limestones at the mouth of the Gordon (Macquarie Harbour), which he regarded as identical with those at the Great Bend (this in error) showed the Macquarie Harbour occurrence to be high in the Silurian, he elevated the Don-Chudleigh limestones to that position (Gould, 1861).

In 1862 Gould published a report on Macquarie Harbour, stated to be of a general nature only. He took the beds of limestone as a key and enunciated the theory that Western Tasmania showed a series of parallel north-south folds, producing a repetition of beds from east to west.

A considerable list of fossils is given. These were taken from a collection made earlier by Dr. Milligan (see Johnston 1888, p. 62), supplemented by those gathered by Gould from the two beds of limestone—one near the mouth of the Gordon, the other at the junction of the Gordon and Franklin Rivers extending several miles thence up both valleys. (See map accompanying the report.) Gould stated that he considered these limestones were identical with those at the Great Bend, but did not advance any arguments in support of this view. He considered the limestone to be underlain by sandstones and grits, and below these occurred a bed of conglomerates (clearly from his descriptions, what we know now as the West Coast Range Conglomerates). He placed the Eldon Valley mudstones as higher than the limestones and records that some similar rock outcrops at the mouth of the Gordon. (It may be stated here for the sake of clarity that the Eldon Valley Series of Gould is what is now known as the Queen River Slate and Sandstone Series, his limestone at the mouth of the Gordon is the Gordon River Limestone Series, the underlying grits and sandstones are the Quartzite Series and the conglomerates, the West Coast Range Conglomerate Series.) So Gould had, as early as 1862, a clear view of what may be termed the "Silurian" succession. His correlation of these beds with the Don-Chudleigh limestones and the associated Caroline Creek Series was followed by some subsequent workers and this has led to some confusion as the latter have since been shown by fossil evidence to be basal Ordovician.

Gould's final contribution was in 1866, when he recorded the fossils which he stated had been identified by Professor McCoy. Unfortunately complete lists were not given and Johnston (1888, p. 62) stated that he failed to locate "these lists elsewhere in any of our local records." Gould's list includes the following:

Orthoceratites
Lituites
Halysites
Favosites
Raphistoma
Orthis

Rhynchonella
Euomphalus
Murchisonia

Other collections had been submitted by Gould to Professor W. J. Salter and 21 species were given manuscript names. These were included in Bigsby's "Thesaurus Siluricus" and in the Catalogue of Australian Fossils by R. Etheridge (1881). They were also listed by Johnston, who states (1888, p. 62) "we are unable to determine to what extent the species still preserved in the Tasmanian Museum are included in the list. . . . "

T. Stephens and R. Etheridge, jun.

T. Stephens (1874) investigated the Caroline Creek district and made a collection which was subsequently described by R. Etheridge, jun. (Stephens 1882). At the same time Stephens forwarded to Etheridge a small collection of fossils from the Table Cape Conglomerates, and these were described in the same report. This paper by Etheridge (1882) contains the original descriptions of many Tasmanian lower Palaeozoic fossils.

It should be noted that Silurian then included the Ordovician and Silurian of modern usage. Although Lapworth proposed the term Ordovician in 1879, as a compromise between the views of Murchison and Sedgwick, the absence of the term Ordovician, except in the table in Johnston's Geology (1888) indicated that the division was not recognised in Tasmania at that time. The fossils described by Etheridge fall into two distinct groups—(a) from Caroline Creek and (b) from Table Cape. It is now known that the Table Cape Conglomerates are of glacial origin and Permian age, so the discovery of fossils in included pebbles is of no great assistance in unravelling Tasmanian stratigraphy.

The following are the determinations:—

Group (a).
Conocephalites ? Stephensi.
Dikelocephalus tasmanicus.
Asaphus (two species).
Ptychoparia? (three species).
Ophileta?
(For a revision of the above see Kobayashi, 1936)

Group (b).
Pentamerus Tasmaniensis (Eth. fil.).
Various *Spirifers.*
Strophomena.
Tentaculites.

These latter determinations indicate that these pebbles are derived from beds in Gould's "Eldon Group." Etheridge assigned an Upper Cambrian age to Group (a) and Upper Silurian age to Group (b).

R. M. Johnston.

The next writer was R. M. Johnston, in the Systematic Geology of Tasmania published in 1888. There we find for the first time in Tasmanian geological literature a comprehensive account of the lower palaeozoic rocks. In 1885 Johnston published a short paper which, however, has been largely incorporated into his Geology. He mentions

the fact that Gould's specimens were identified by McCoy (a fact indicated by Gould but without reference to McCoy's actual report on the specimens), and that Gould regarded these Gordon River limestones as at "the very base of the lower Silurian of Europe, anterior to the described fossiliferous beds of Victoria, as well as the Calymene-containing beds of the Eldon Valley." The fossils show, however, that the beds are Silurian in age, and not at the base of the lower Silurian (=Ordovician of modern nomenclature). Johnston also mentions the earlier determination by Professor Salter in 1868 of 28 species. These are all fossils typical of the Gordon River Limestone suite, but the exact locality of the collection does not appear to have been recorded, and the list of Salter's description copied by Johnston in the paper under discussion is unaccompanied by illustrations. Johnston gives figures of many of these genera in Plates IV, V, and VII of his Geology, but as he does not credit Salter with any of the types there illustrated, it appears as if he figured other specimens for this work.

The fossils described by Salter as Straparollus and figured by Johnston (Geology Plate V) are more typical of the Junee suite (to be described later), but the others are typical Gordon River forms. Salter's collection may thus have come from more than one locality.

TABLE 1—SUMMARISING JOHNSTON'S IDEAS AS TO THE GEOLOGICAL SUCCESSION

UPPER SILURIAN (=Silurian of modern usage)	ELDON GROUP	Fingal Slates Eldon Valley Clay Slates and Mudstones Dial Range and N.W. Coast Conglomerates Queen River Formation
LOWER SILURIAN (i.e., Ordovician of modern usage)	2. Cordon River Group	Fossiliferous limestones, slates, grits, conglomerates, and quartzose sandstones at Point Hibbs Franklin River Florentine Valley
	1. Auriferous Slate Group	Auriferous felspar porphyries, Lymington Auriferous slates, etc. Beaconsfield, Lefroy, the Don, Waterhouse, Denison, Back Creek, Gladstone, Mathinna, Mangana, Mount Victoria.
CAMBRIAN	3. Primordial Calciferous Group 2. Magog Group 1. Dikelocephalus Group	Limestones of Chudleigh, Belvoir, Ilfracombe, etc. Sandstones and alum schists of Chudleigh (Magog Range, etc.). Caroline Creek grits and sandstones.

The palaeontological evidence given by Johnston is summarised below:—

CAMBRIAN.

Dikelocephalus Group. (The fauna of this group has been reviewed in detail by Kobayashi and no useful purpose will be served by listing the old names.)

Magog Group. No fossils were found, but he maintained the rocks were closely related to the "Dikelocephalus Group" and may yet prove to be the same.

Primordial Calciferous Group. These rocks had yielded no fossils and he expressed doubt as to the position of these Cambrian rocks. He considered that at Don, Chudleigh and Magog Mountain, the sandstones and limestones are closely in association with the "Dikelocephalus" bearing Caroline Creek Group. He notes that Gould started with this idea, but later correlated these limestones with the Gordon River limestones. Johnston reverts to Gould's original idea.

Lower Silurian (Ordovician).

Auriferous Slate Group. He mentions the Beaconsfield slates and grits with Licrophycus and at Lisle, *"Diplograptus nodosus"* (not now accepted) and a bed "replete with orthis."

Gordon River Group. Johnston's remarks (1888, pp. 61-63) are a repetition of his 1885 paper, and he adds nothing to the observations of Gould, McCoy, Salter and Etheridge there recorded.

Upper Silurian.

Eldon Group—Queen River Formation.

Johnston identified:

Spirifera crispa (Hesinger) (sic).
S. plicatella (Linn).
Orthis flabellum.
O. elegantula.

Dial Range and North-West Coast Conglomerate

He points out that the fossils in these were derived from the Queen River formation. It is now considered that the Dial Range is capped by the West Coast Range Conglomerate, while the north-west Coast Conglomerates are of glacial origin and Permian age.

Eldon Valley Clay Slates and Mudstones.

Johnston merely repeats Gould's observations of Calymene, Orthis and Cardiola, etc.

Fingal Slates.

The only fossil mentioned is a "species of *Anodonta,*" closely resembling *A. Jukesii* found in the Devonian rocks of Ireland (p. 67). (In his comparative table (p. 78) he also includes these beds in the Upper Devonian and mentions the soft slates, Fingal with *Anodonta Gouldii* and undetermined plant impressions, and refers doubtfully to the Devonian age of the Eldon Valley mudstones. The high position of the Eldon Group and the Fingal Slates appears to be supported by additional information obtained in recent years.)

Johnston figured many of these fossils, which may be assigned to horizons in Nye and Blake's 1938 classification as follows:—

Plate I. Caroline Creek Series.
Plate IV. Gordon River Limestone Series.
Plate V. Gordon River Limestone and Queen River Slates and Sandstone Series.
Plates VI and VII. Queen River Slates and Sandstone Series and Discoidal Series.

R. Montgomery and R. Etheridge, jun.

The next important contribution to the unravelling of the Cambro-Silurian succession in Tasmania was made in 1896, again by R. Etheridge, jun. R. Montgomery, then Government Geologist, collected a suite of fossils from Zeehan and Heazlewood. Etheridge described this comprehensive collection and very few collections of lower Palaeozoic shelly fossils have since been fully described from Tasmania.

Trilobita.

Asaphus.
Hausmannia meridianus Eth. jun. and Mit.
Amphion ? brevispinus Eth. jun.
Illaenus Johnstoni Eth. jun.
From Despatch Limestone, Zeehan.
Cromus Murchisoni De Kon.
From blue-grey schistose rock, Zeehan, and from Heazlewood.

Gasteropoda.

Murchisonia D'Arch and De Vern.
Lophospira Whitfield.
Raphistoma Hall.
Eunema Montgomerie Eth. jun.

Brachiopoda.

Rhynchonella decemplicata Sowerby.
R. cuneata Dalman.
R. capax var. *meridionalis* Eth. jun.
R. borealis Schlotheim.
Strophomena sp. Rafinesque.
Stropheodonta sp. Hall.

Pteropoda.

Tentaculites Schlotheim.

Corals.

Favosites grandipora Eth. jun.
Pleurodictyum? Goldfuss.

Vermes.

Cornulites Tasmanicus Eth. jun.

These fossils are typical of the rocks above the West Coast Range Conglomerate Series.

R. Etheridge and T. Stevens.

The next advance was a description by Robert Etheridge of a new find of trilobites by Thomas Stevens from Florentine Valley (Etheridge jun. 1904).

He described a new species of trilobite, *Dikelocephalus florentinensis* Eth. jun. (now *Asaphopsis florentinensis* (Eth.) see Kobayashi 1936) and recorded the form now known as *Tasmanocephalus Stephensi* Etheridge. He also figured specimens of *Orthis lenticularis* Wahlenberg, which is typical of these beds. These descriptions establish the close similarity between the Florentine Valley series and the Caroline Creek series.

W. H. Twelvetrees and L. K. Ward.

In 1900-1901 W. H. Twelvetrees contributed a valuable summary of our knowledge of Tasmanian Geology, the first since Johnston's Geology had appeared in the Outlines of the Geology of Tasmania. In this work he placed the Caroline Creek sandstones as Cambrian

and grouped all the other known lower palaeozoic rocks as Silurian. At the base of this group he placed the Gordon River Limestones, which he grouped with the Railton-Chudleigh Limestones, etc., and the Beaconsfield Lefroy-Mathinna slates and sandstones. All these he termed Lower Silurian. The balance were placed in the upper and middle Silurian, and included the Lyell schists, conglomerates, etc., Dundas and Mt. Read slates, etc., brachiopod sandstones of Middlesex, Heazlewood, Queen River and Zeehan, in that order.

In 1907-1908 Twelvetrees and Ward inspected a section of country over which the Great Western Railway Company was asking for concessions. This extended from Glenora to the Serpentine and via King William Range to Linda, thus giving an east west section across the country occupied by lower palaeozoic rocks. This section, which included the trilobite beds of the Florentine valley, will be dealt with later. Their observations, however, remain as the only detailed report on much of the country covered (Twelvetrees 1908).

In 1909 Twelvetrees contributed observations on the mining fields of the north-west, dealing with the older rocks of the Lower Palaeozoic succession, and in 1910, in collaboration with Ward, with the younger rocks of this succession in the Zeehan area.

His 1909 paper was written after his discovery of the trilobites described by Etheridge (1904), who had referred them to the Upper Cambrian. He discussed the relationship between the Caroline Creek and Railton limestones, regarding the Caroline Creek sandstones at Blenkhorn's quarry, Railton, as "passing apparently conformably below the Lower Silurian limestone (Gordon River Series)." He recorded a trilobite fragment from the quarry and *Raphistoma* from Railton township.

At Gunn's Plains he described the limestone as resting on a series of cherty conglomerates, breccias, tuffs and chocolate coloured slates and described a conglomerate series from the Leven Gorge which he differentiated from the West Coast Range Conglomerate Series.

He correlated the Leven series with the conglomerates outcropping at Penguin, and he considered the conglomerates of Stowport and Blythe iron mines to be part of the same group. He also correlated the Gunn's plains limestone with that at Mole Creek and assigned them both to the Gordon River Series. He recorded the occurrence of *Actinoceras* in the Railton limestones which he correlated with the Gordon River Series on Gould's palaeontological observations, but agreed with Gould that it is at the very base of the Lower Silurian (i.e., Ordovician). A useful comparative table of succession is given on page 35, and this appears substantially upheld by observations to the present date with the exception of the correlation of these limestones with the Gordon River Series.

Twelvetrees from time to time published most useful summaries of the stratigraphical Geology of Tasmania, bringing his ideas on the succession up to date. The last of these was published in 1909 and was generally accepted until the publication of a summary by P. B. Nye and A. N. Lewis in 1928. In his 1909 "Outlines" (p. 122) Twelvetrees stresses, with full reasons, his view that the West Coast Range Conglomerate Series lies well below the Caroline Creek series and assigns a position low in the Cambrian for this. He recognises that

the West Coast Range Conglomerate Series is succeeded first by the Tubicolar Sandstones and that rock by the Discoidal Sandstone. The Dundas and Leven slates and breccias or the considerable beds round Tim Shea and Mt. Mueller towards the south-east are among his "incertae sedis." Twelvetrees gave an Ordovician age to the Gordon River limestones (based on observations at Railton) and classified all the major beds of lower palaeozoic limestones as of this series. Succeeding this he placed the Fingal-Mathinna-Warrentina suite of rocks, also assigning them an Ordovician age. He assigned a Middle Silurian age for the Eldon Valley-Queen River-Zeehan-Heazlewood limestones and sandstones from which fossils had been obtained, but recorded little in the way of data bearing on the succession of different stages or rocks of different localities in this group.

SILURIAN.
- Eldon Valley Clay Slates.
- Fossiliferous limestone, sandstone and slate at Zeehan, Heazlewood, Queen and Nelson River, etc.

ORDOVICIAN.
- Slate and Sandstone in the Goldfields of Lefroy, Mt. Victoria, Mathinna, Mangana.
- Limestone on the Gordon, Florentine, etc., at Railton, Mole Creek, Beaconsfield, etc

CAMBRIAN.
- Incertae sedis.
  - Dundas slates and breccias; the Dial Range and Leven slates, etc., the felspathic porphyries of Mt. Lyell, etc.
  - Slates and sandstone at the Needles and near Mts. Mueller and Wedge.
- Dikelocephalus sandstone at Caroline Creek, etc.
- Discoidal sandstone, Loddon River and Caroline Creek.
- Tubicolar sandstone at Middlesex, Five Mile, etc.
- Conglomerates, of the West Coast Range, the Thumbs.

PRE-CAMBRIAN.
- Amphibolites and quartzitic schists, etc.

In 1910 a revision of the rocks around Zeehan was made by Twelvetrees and Ward. Their succession is as follows:—

SILURIAN.
8. Pale and dark coloured slates and sandstones.
7. Sandstones, pebbly grit, and greenish grey slate.
6. Limestone.
5. Shale and slate.

UNDETERMINED (ORDOVICIAN?).
4. Sandstones and slate of the Nubeena and Queen Hills.

CAMBRO-ORDOVICIAN.
3. Tuffs, breccias, spilitic lava flows, slates and sandstones.

CAMBRIAN.
2. Tubicolar sandstone.
1. West Coast Range Conglomerate series.

The low horizon of the Conglomerate series was based on the assumption that they were identical with the Denison Range-Thumbs rocks (i.e., outcrops near the Great Bend). Their position inferior to the Dundas Slates is also not acceptable to later workers.

Their lists of Silurian fossils are interesting and are given below.

Those from the limestones and determined, for the most part at least, by R. Etheridge, jun., are:—

TRILOBITA.
Asaphus. sp. ind. Despatch Limestone.
Hausmannia meridianus (Eth. & Mit.). Despatch Limestone.
Illaenus Johnstoni (Eth.). Despatch Limestone.
Amphion (?) *brevispinus* (Eth.). Despateh Limestone.

CEPHALOPODA.
Orthoceras sp. Despatch Limestone.

GASTEROPODA.
Trochonema (*Eunema*) *montgomerii*. Despatch and Smelters.
Raphistoma spp. Smelters.
Hormotona sp. Smelters.

PELYCYPODA.
Leptodomus (?) *muciformis* (Eth.). Despatch.
Palaeoncilo sp. Smelters.

BRACHIOPODA.
Rhynchonella borealis var. nov. Smelters.

VERMES.
Cornulites. Smelters.

COELENTERATA.
Favosites (?). Smelters.

The list by W. S. Dun, from the overlying beds, is larger:—

TRILOBITA.
Calymene (close to if not identical with *C. blumenbachii* (Brong))
Cromus murchisoni (de Kon) Mit.
Hausmannia meridionalis (Eth. & Mit.).

CEPHALOPODA.
Orthoceras sp.
Actinoceras sp.

PTEROPODA.
Tentaculites sp.

GASTROPODA.
Murchisonia.
Raphistoma sp.
Lophospira spp.

PELYCYPODA.
Tellinomya jonesi (Johnston).

BRACHIOPODA.
Strophomena sp.
Dalmanella sp.
One of the Meristidae.
Camarotoechia sp.
Pentamerus tasmaniensis (Johnston).
Spirifera of the *S. sulcata* group.
Spirifera of the *S. cristata* group.
Strophodonta sp.
Trematospira tasmaniensis sp. nov.
Rhynchonella borealis var. nov.
Retzia (?).

VERMES.
Cornulites tasmanicus (R. Eth.).
Annelida (?) (Pipestems).

CRINOIDEA.
Crinoid ossieles, stems, etc.

COELENTERATA.
Zaphentroid or Cyathophylloid (casts).
Halysites (casts).
Favosites (casts).
Pleurodictyum.

He gave the range of the various forms and concluded they indicated a Silurian age, though most probably low, for the Zeehan rocks.

These lists are important, as very little palaeontological work has been carried out on these shelly faunas since this date, so that they form the basis of the faunal lists which have been quoted later. It is very unfortunate that many of these forms have not been described or figured, and all will need revision on modern palaeontological lines. The general similarity to the Yeringian of Victoria is very noticeable, so that the beds are higher in the sequence than generally accepted.

Second Period, 1910-1930

In the earlier period stratigraphical and palaeontological investigation went hand in hand. The results of the studies of the mining fields appear for the most part in the Bulletins of the Geological Survey which commence in the year 1907. In the earliest of these attention is paid to palaeontological identifications, but after 1910 attention was concentrated on mining problems rather than stratigraphic ones. It is not intended to refer to all these reports, but only to those that first advance new ideas.

L. K. Ward, in 1911, contributed a description of another group of lower palaeozoic rocks which he called "The Balfour Slates and Sandstones," and to which he assigned a Cambro-Ordovician age based on the fact that they are penetrated by basic dykes (at that time provisionally considered to be Cambro-Ordovician). Associated with the Balfour Slates and Sandstone series are conglomerates and some limestone, both of unidentified age.

The next important contribution was made by Loftus Hills in 1914. Hills working in the Jukes-Darwin Range, subdivided the West Coast Range Conglomerate Series into a lower brecciated conglomerate and an upper or normal conglomerate. He considered that the lower brecciated conglomerate contained fragments of the porphyroid igneous suite, at that time thought to be Cambro-Ordovician, and considered that the breccia conglomerates rested "unconformably on the upturned edges of the porphyroids." He regarded the two stages of the series as conformable, and recorded Silurian sediments identified by their fossil contents, on both sides of the Range (as is the case further north). He then (p. 59) advanced reasons for placing the whole West Coast Range Conglomerate Series between the porphyroids and the Gordon River Limestone Series, discussing and rejecting a number of other possibilities. Hills then gave a pre-Silurian age to the West Coast Range Conglomerate Series, the deposition of which was preceded by a major period of diastrophism. Similar features and relationship of the West Coast Conglomerate Series at Mt. Murchison were later recorded by the same writer (Hills 1915).

The Dundas Slate Series was described by Hartwell Conder (1918), who regarded them as Cambro-Ordovician on the slender evidence of the graptolite thecae (recorded by T. S. Hall in 1902) found in rocks of this series on the North West Dundas tram-line.

The Dundas Slates and West Coast Range Conglomerate Series as developed in the north-west (south and west of Sheffield and Wilmot)

were described by MacIntosh Reid (1919), who established an unconformity here between the Dundas Slates and the West Coast Range Conglomerate Series and indicated that the latter are subsequent to the porphyroid group of igneous rocks. Some Silurian trilobites, *Rhynchonella* and *Orthis*, were identified from clayey sandstone associated with limestones at Bell Mount, indicating an age later than the Tubicolar Sandstones.

In 1919 F. Chapman described a new coral *Tetradium tasmaniense* Chapman from the Limestone on Smelters Road, Zeehan. This is the Despatch limestone of Montgomery and Etheridge. Chapman assigns an upper Ordovician or basal Silurian age for this fossil, and it is also interesting to note that he calls this Zeehan limestone "Gordon River limestone."

The next general summary was published by Loftus Hills in 1921. Except for a few paragraphs on the position of the West Coast Range Conglomerate series, this summary adds nothing material to the accounts above abstracted.

P. B. Nye (1923) described the Dundas Series and the Bischoff Slate and Sandstone series (correlated with the Balfour Series) as occurring round Mt. Bischoff. Both Nye and Hills throw grave doubt on the age determination of the Dundas Series as based on Hall's graptolites, but indicate that it lies quite definitely between the schists assigned to a pre-Cambrian age and the West Coast Range Conglomerate Series assigned to a Silurian age, with marked unconformities marking both extremities. Nye places the Bischoff Series as younger than the Dundas Series and assigns to it an Ordovician age. Silurian strata, similar to those at Zeehan, etc., with fossils typical of these rocks as developed elsewhere, are also recorded.

This account was supplemented and confirmed by McIntosh Reid in 1923, who gives a further account of the Dundas Slates and Bischoff series. The latter are stated to be separated from the former (earlier) series by an unconformity.

The extensive tract of old rocks in the south-west of the State was also not neglected. McIntosh Reid described these near Adamsfield (Reid 1921), and in 1923 A. N. Lewis described the country around Mt. Anne. Neither author described fossils by which the age of the rocks could be determined.

In 1924 appeared the next contribution of major importance to the unravelling of the Cambro-Silurian succession problem. This was a tentative opinion by McIntosh Reid that perhaps the Railton-Don limestones were not properly assigned to the Silurian Gordon River Limestone Series, reverting to Gould's first opinion and Johnston's view. In this he was not influenced by the discovery of fossils, but of a dyke belonging to the porphyroid series which cut limestones near the Paloona Pumping Station. At this time these igneous rocks were supposed to be older than the West Coast Range conglomerates. As they intrude the limestones here, these must be older than the typical Gordon River limestones which overlie the Conglomerates. He discussed the age of the limestones at some length (pp. 22-26), and advanced the opinion that they are of Ordovician age, thus separating them from those near Zeehan. He also correlated the conglomerates of the Mersey valley with the West Coast Range Con-

glomerates (thus differing from the views expressed by Twelvetrees 1909), although he was correct in comparing them with Johnston's "Magog" Series.

In 1925, Reid identified the Bischoff Series in the Dundas district, but now advanced the view that it was older than the Dundas Slates, thus reversing the succession as propounded by Nye.

In 1925, F. Chapman described (?) *Hurdia davidi,* found by Sir Edgeworth David on the Emu Bay Railway, four miles south of Hatfield Plains. On this slender evidence he assigns to these rocks a Middle Cambrian age.

In 1928, he described some well-preserved annelid trails as a new genus and species *Tasmanadia twelvetreesi,* to which he gave a Cambrian age.

In 1928 there appeared a general summary of Tasmanian Geology by P. B. Nye and A. N. Lewis. This gives the views then generally held as to the succession, which is summarised in the following table:—

MIDDLE SILURIAN.

Queen River Slates and Sandstones.
At Zeehan, valley of Queen River, Heazlewood and Middlesex Plains.

Gordon River Limestones.
Lower Gordon River, Chudleigh, Mole Creek, Ulverstone, Railton, Florentine River, Junee, and Ida Bay.

Tubicolar Sandstone or Quartzite Series.
Lies between the overlying limestones and underlying sandstones.

West Coast Range Conglomerate Series.
These form the base of the Silurian Rocks.

CAMBRO ORDOVICIAN.

Diastrophic Period.
(a) Porphyroid igneous complex.
(b) Read Rosebery schists.
(c) Dundas Slates.
(d) Mathinna slates and sandstones.
(e) Balfour slates and sandstones.

CAMBRIAN.
(a) Dikelocephalus sandstones of Caroline Creek.
(b) Dikelocephalus sandstones of the Florentine Valley.
(c) Slates of Hatfield Plains.

Nye and Lewis present several lists of fossils (unfortunately with some typographical errors). As the exact localities are not given, and as many of the forms have not been illustrated, it is difficult to comment on these lists. Some of the forms, however, e.g., *Pleurodictyum,* would indicate a higher horizon than the authors would give their "Silurian" beds, which thus may extend into the Lower Devonian and would be comparable with the Yeringian of Victoria.

No fossils are recorded from the Tubicolar Sandstone or the underlying Conglomerates.

It is pointed out that several groups of rocks included in the Cambro-Ordovician have yielded no fossils and so cannot be correlated with each other. The limestones at Railton, however, are correlated with the Larapintine as they contain *Actinoceras* cf. *tatei* and *Trochoceras.*

No new records for the Cambrian are given, but they state that Dr. F. Whitehouse was examining the fossils and had suggested that *Tsinania* was present.

P. B. Nye published a most important contribution to the Palaeozoic problem in 1929, when describing Adamsfield. Prior to this account, with the exception of the brief references by Twelvetrees in 1908, no important discoveries of the Silurian series, other than some doubtful references to the West Coast Range Conglomerate Series along the North-West Coast, had been made east of the great pre-Cambrian axis which runs northwards from Port Davey past Frenchman's Cap to Cradle Mountain. Nye considered that considerable occurrences of the Gordon River-Queen River Series occur at Adamsfield.

The basis of Nye's correlation is the identity of the conglomerates of the Thumbs-Saw Back Range, with a second parallel ridge to the west. These he assigns to the West Coast Conglomerate Series. Doubt was cast on this correlation by Lewis (1940), and fossil evidence obtained at Adamsfield by Thomas (1943) showed that the limestones were basal Ordovician in age. They are thus the repetition to the west of the Junee and Florentine beds, with their *Tasmanocephalus* fauna.

It should be noted that Nye's fossil collections from Adamsfield have not yet been described (Nye, personal communication) a task which should shed much light on the Ordovician succession.

Third Period, 1930 Onwards

This period was initiated by the structural work of the Tasmanian Geological Survey in the north and west of the State and by the work of A. N. Lewis in the south. The palaeontological work is by workers outside Tasmania, and marks the beginning of modern palaeontological research in that State.

1932. Sir T. W. Edgeworth David gave a useful summary of his ideas as to the sequence, which is as follows:—

Silurian.
- Yeringian.
  - Zeehan sandstones.
- Melbournian.
  - Gordon limestones.
  - Despatch limestones.
  - Limestone of Lyell and Zeehan.
  - Tubicolar sandstones.
  - West Coast Range Conglomerates.

Ordovician.
- Dundas Series with *Callograptus* sp.
- Limestones of Blenkhorn's Quarry, with large Cephalopods.

Cambro-Ordovician.
- Dundas Slates with Hurdia (possibly Middle Cambrian).

Cambrian.
- Upper (Tremadocian).
  - Caroline Series, with Asaphellus, Tsinania, Crepicephalus, etc.

K. J. Finucane (1932) distinguished a Rosebery or Pre-Dundas Series, which underlies the Dundas Series, and showed that the porphyries as well as some basic rocks were intrusive into the Lower Palaeozoic sediments.

In 1934, in the Bulletin on the Smithton Area (Nye, Finucane and Blake) a group of slates that was correlated with the Dundas Series was described. Above this is the Dolomite, and beneath it the

Chert Stage. Beneath the latter is a considerable thickness of beds divided into —

2. Grey Green Quartzite Stage,
1. White Quartzite Stage.

No fossils were found, but the beds are considered to be conformable, although there may be an unconformity between the Quartzite Stages. The sequence is interesting, as it shows for the first time a downward succession to beds formerly correlated with the Proterozoic period.

In 1936 T. Kobayashi, in reviewing the fossils from the Mersey River district, proposed the new genus *Tasmanocephalus,* and maintained that the beds were Ordovician in age.

In the same year, Dr. I. Cookson described the fossil plants found by F. Blake at Warrentina, and compared them with *Hostimella* and *Hedeia,* and inferred that the beds were Upper Silurian or Devonian in age.

The most recent summary of Tasmanian Geology, and the most complete that has been published since Johnston's Geology, is that by Nye and Blake (Geological Survey Bulletin No. 44, 1938). They subdivide the Lower Palaeozoic rocks as follows:—

SILURIAN.
- VI Queen River Slate and Sandstone Series.
- V Gordon River Limestone Series.
- IV Discoidal Series.
- III Quartzite Series.
- II Pipe Stem or Tubicolar Series.
- I West Coast Range Conglomerate Series.

ORDOVICIAN.
- Dundas Slate Series.

CAMBRO-ORDOVICIAN.
- Balfour Series Slates, Quartzites and Conglomerate (but ? Silurian).
- Mathinna Slates and Sandstones (but ? Silurian).
- Rosebery Series.
- Sisters Hill Series.
- Farrell Slates.

CAMBRIAN.
- IV Caroline Creek Sandstone Series.
- III Florentine Valley Slate Series.
- II Hatfield Plains Slate Series.
- I Arthur River Slate Series.

They discuss the relationship of the various rock groups, bring the lists of fossils up to date and mention unpublished identifications by R. Etheridge and F. Chapman. From these lists (which unfortunately contain many typographical errors) it can be seen that descriptions of many of the genera and species have not been published for Tasmania. For full details, which will not be given here, the above publication should be consulted.

A. N. Lewis in 1940 described in some detail the geology of the Tyenna Valley. This is a contribution of great importance, as the collections he made were sent to T. Kobayashi, who described the fossils and established their Lower Ordovician age. They were also examined by Dr. Whitehouse, who also assigned them a low Ordovician age (p. 48). Lewis proposed the Junee Series for these rocks, and his sequence for these rocks is as follows:—

3. Junee Series.
   iii Blue Junee Limestone.
   ii Yellow mudstone containing trilobites and other fossils of Lower Ordovician age.
   i Quartzites with conglomerates and breccias interbedded.

2. Probable Unconformity.

1. Grey Slates Probably Referable to the Dundas Series.

He also cast doubt on Nye's age determinations at Adamsfield and suggested that the rocks there are part of the Junee Series.

1940. T. Kobayashi described collections sent him from Caroline Creek and Junee by A. N. Lewis. From Caroline Creek he listed two genera of brachopods, two of gastropods and five genera of trilobites—

Euomphalid.
Cryptolites sp.
Tasmanocephalus stephensi (Etheridge).
Asaphus sp.
"Asaphellus" lewisi Kobayashi.
Etheridgaspis carolinensis (Etheridge).
E. johnstoni (Eth.).
Carolinites bulbosa (Kob.).
C. quadrata (Kob.).
C. (?) *tasmanicus* (Eth.).
Prosopiscus subquadrata (Kob.).

From Junee he lists—

Orusia (?) sp.
Sinuopea (?) sp.
Roubidouxia (?) sp.
Lecanospira tasmanensis Kobayashi.
Asaphopsis juncensis Kob.
A. (?) *gracicostatus* Kob.
Tasmanaspis lewisi Kob.
T. longus Kob.

He concluded that the faunas of Caroline Creek, Junee and Tim Shea are all Lower Ordovician, with the Caroline Creek beds slightly the oldest (in his paper in the Japanese Journal of Geography and Geology, 1940).

In 1941, Hill and Edwards identified the following fossils from Queenstown—

Alveolites sp.
Protarea cf. *richmondensis.*
Acidolites sp.
Tetradium tasmaniense Chap.
Acantholites sp.

and suggested that the beds were Upper Ordovician or Lower Silurian. The fossils referred to above had been previously commented on by R. B. Withers (Edwards 1939).

In 1942, D. Hill described some Tasmanian Palaeozoic Corals, and in the following year repeated her views in her paper, "A Re-Interpretation of the Australian Palaeozoic Record, based on a Study of the Rugose Corals."

Her age determinations for Tasmania are briefly as follows:—

Upper Ordovician or ? Silurian.

Chudleigh Limestone, Liena, Mersey Valley, with *Favistella*, *crinoids* and *tabulate corals*,

Grey Limestone at head of Nelson River, with one tabulate form.
Old Queenstown Flux Quarry with *Tetradium*.
Limestone on Smelters Road, Zeehan, with *Tetradium*.

SILURIAN, UPPER WENLOCK AND POSSIBLY LOWER LUDLOW.

Limestone of the Gordon River with two species of *Rugosa*.

SILURIAN AND/OR DEVONIAN.

Point Hibbs, with *Heliophyllum ? chillagoense* and *Favosites ? bryani*.

LUDLOVIAN OR PROBABLY LOWER DEVONIAN.

Zeehan, with *Pleurodictyum megastomum*.

D. E. Thomas and Q. J. Henderson in 1945 described hydroids and dendroids and recorded fragments of trilobites from the Dundas slates. The following forms were identified:—

Archaeocryptolaria skeatsi Chapman.
Masligograptus sp.
Cactograptus flexispinosus Chapman and Thomas.
Protohalecium hallianum C. and T.
Sphenoecium filicoides (Chap.).
Sphenoecium sp.
? Protistograptus.

From the similarity of these forms to those found in Victoria in undoubted Middle Cambrian rocks the authors conclude that the Dundas Series must be of Cambrian age.

In the same year Thomas reviewed the evidence for the occurrence of graptolites in Tasmania, and came to the conclusion that none of the records can be substantiated, and that T. S. Hall's record from Dundas falls in line with the determinations of dendroids as listed above.

The Porphyroid Suite of Igneous Rocks

These are a suite of plutonic, hypabyssal and, according to some of the workers, even volcanic rocks. As a group they are important in the mining fields in the western part of the island. Many opinions as to the age of these rocks have been expressed, based mainly on their general relationship to the sedimentary rocks. L. Hills, in 1914, as a result of observations south of Linda, and a review of the ideas of earlier workers, stated that they had been consolidated, weathered and subjected to diastrophic movements prior to the deposition of the West Coast Range Conglomerate Series, and so were assigned an Ordovician age. Several other workers, assuming the Ordovician age as proved, have used this igneous suite as a basis for the correlation of some of the sedimentary series.

Work by K. J. Finucane in the Rosebery district (1932) and by P. B. Nye, F. Blake and Q. J. Henderson in the Lyell area is indicated in Bulletin No. 44, 1938, pp. 36, 41, 42. (Details of this are not published but are in the mss. reports by these authors.) They maintain that these igneous rocks are intrusive into the Silurian and that the schistosity was due to the same diastrophic movements

that folded these older rocks (see also H. J. C. Conolly 1940, who holds similar views). Thus the schists of Lyell, the Queen River, and Read-Rosebery, the "porphyroid igneous complex" and the felsites and keratophyres so important in the mining fields and so fully discussed in many of the Survey Bulletins, become the minor intrusions associated with the granitic intrusions of post-Devonian times.

The evidence of contemporaneous volcanic activity in the Dundas Slates has never been doubted, and there is a possibility that this igneous activity has not been differentiated from the younger in all cases.

All the age correlations based on these igneous rocks should thus be considered very doubtful, and have not been considered in the present discussion.

Discussion of the Lower Palaeozoic Succession

The Upper Beds

The Silurian-Devonian Fossiliferous Beds.

A convenient starting point for a discussion on the lower palaeozoic Succession in Tasmania is the limestone in which Gould found his type fossils, and which is well developed round Macquarie Harbour and Zeehan. This is distinguishable by certain clearly recognisable fossils indicating an age either Silurian or early Devonian.

These fossils are found in great quantities in certain layers of blue limestone and white sandstone occurring principally to the west of the West Coast Range. The typical limestones are at the mouth of the Gordon and Franklin Rivers, and have been called the Gordon River Limestone Series, which is clearly identifiable from the fossil assemblage. From these localities on the Gordon, beds containing similar fossils and clearly referable to the same series occur, with some breaks, northward to Zeehan, and with some isolated occurrences at Heazlewood and Eldon Valley.

They are particularly well developed between Queenstown and Strahan (Queen River area) and at Zeehan. In the latter areas, beds of limestone are interbedded with thick sandstones, grading sometimes into quartzites, and with thinner beds of grey slate. In the Queenstown and Strahan areas they are intruded by basic and acid rocks, the "porphyroids," now themselves in places metamorphosed into schists.

At both Zeehan and Queenstown the limestone beds are interbedded with the sandstones, which in places are also very fossiliferous. It was from such beds that Montgomery and Twelvetrees collected the fossils already referred to (Etheridge 1896, Chapman 1919).

The succession is not known in detail, but it appears that the blue limestones are developed as lenses, and although the same general suite of fossils characterises these rocks, until detailed modern palaeontological research is carried out it is difficult to determine their exact horizons. This series includes Johnston's Lower Silurian and Upper Silurian (Johnston 1888, p. 54) subdivided by Twelvetrees into the Discoidal Series, the Gordon River Limestone Series and the Queen River Slate and Sandstone Series, and which are more fully described by later authors (Nye and Blake 1938). The Gordon River limestones are well developed in the localities on the Gordon, but at

Zeehan they appear to be lenses in the sandstone, slates and quartzites which may be the Queen River Slate and Sandstone Series.

It appears, therefore, that in some areas the series contains a very thick development of limestone, but in other areas the limestones are thin or absent. The whole series, thus, consists of rapid alternations of limestone, sandstones and slates.

The following, from the general similarities of their fossils, can be considered as belonging to one series:—Blue limestones of the lower Gordon Valley (Gould 1860, 1866) (but not those of the Great Bend of the Gordon); the rocks showing the fossil suite referred to, which lie between the Gordon River and Strahan and thence to Queenstown and the valley of the Queen River and extending west of the mountains (i.e., over the Henty peneplain) to Zeehan; the rocks at Zeehan (Etheridge 1896, Twelvetrees and Ward 1910, Chapman 1919); the rocks at Heazlewood (Etheridge 1896) and Middlesex (Reid 1919) and Gould's "Calymene" beds of the Eldon Valley.

West Coast Range Conglomerate Series.

These have been divided into three conformable lithological groups:

3. Tubicolar Sandstone.
2. Normal Conglomerate.
1. Lower Brecciated Conglomerate.

(Further subdivisions, however, have been proposed in unpublished work by Conolly, see Edwards 1943.)

Although forming an easily identifiable lithological group, the age determinations given this group have ranged from Lower Cambrian to Upper Silurian.

The type locality is that part of the West Coast Range from Mt. Murchison to Mt. Sorell. Here there appears to be little doubt as to the horizon and relationship of the series, but there is a possibility that beds of conglomerates of the same general appearance exist in many parts of the State at a different geological horizon, and confusion has arisen from this factor.

The assignment of the West Coast Conglomerate Series to a position unconformably overlying the rocks containing asaphid trilobites (Lower Ordovician) and conformably underlying the rocks containing phacopid trilobites (Silurian) is the most reasonable, and has been adopted by Nye and Blake (1938, p. 37), who stated that this series "unconformably overlies the Dundas and other Cambro-Ordovician series and underlies the fossiliferous Silurian rocks." This stratigraphical horizon was suggested by G. A. Waller in 1903 and definitely assigned to it by Loftus Hills in 1914.

Owing to the absence of fossils, the exact age of this group cannot be determined. If some of the limestones (D. Hill 1943) to the west of the West Coast Range, and if the King River Series (Nye, Blake and Henderson (manuscript report 1934) are Upper Ordovician, the age can be fixed within narrow limits, and can be considered broadly as Silurian.

The beds succeeding the conglomerates or into which they pass laterally are the Tubicolar Sandstones. Previous opinion assigns an annelid origin to the tubes that characterise these beds (Twelvetrees and Ward 1910, pp. 28-30), but these are of no aid in age determinations.

Reid (1919) records shelly fossils typical of the Gordon Zeehan rocks from beds at Bell Mount (in the Middlesex area) which succeed the Tubicolar Sandstone stage. No detailed account of the succession is given, and L. Hills (1914, p. 54) is equally indefinite in regard to the upward succession at Jukes-Darwin and Crotty. Twelvetrees and Ward have described the series occurring round Zeehan, but do not record any section which shows a continuous succession (Twelvetrees and Ward 1910, pp. 33-39). L. Hills (1921, p. 121) maintained that the Gordon-Zeehan series succeeded the Tubicolar sandstone conformably, and Nye and Blake (1938, p. 38) also hold this view.

Published records of the actual contact of the conglomerates with the underlying beds are few, but all observers agree that it is an unconformity.

L. Hills (1914) stated that these rocks rested unconformably on volcanic rocks which must have been extruded subsequently to the formation of the Dundas Slates. With the identification at Junee-The Needles-Tim Shea of beds of conglomerate not easily distinguishable from this series, but overlain by limestones and sandstones bearing asaphid trilobites of Lower Ordovician Age, and the removal of Hills' basis of classification by the discovery of a later age and intrusive nature for the igneous rocks, doubt arises as to whether all the conglomerates called the West Coast Range Conglomerates Series are correctly correlated.

Thus Twelvetrees considered that the conglomerate occurring on the Thumbs-Denison Range dipped under the limestone of the Florentine Valley. (Twelvetrees, 1908, vide Section 3-4.) As he considered that the limestone was of Ordovician age, he assigned a Cambrian age to the conglomerates. Later the Florentine limestone was identified with the Gordon River limestone series and the conglomerates with the West Coast Range conglomerate series (Twelvetrees and Ward 1910, pp. 33-34; Nye 1929, pp. 11-12).

A. N. Lewis (1938) expressed doubt that this wide correlation of the conglomerates at Adamsfield with the West Coast Range conglomerate was justified, and that the sequence at that place would be correlated with the Junee Series and the lower Conglomerate. This view has been proved correct by further work in this area (Thomas, Thomas and Henderson, 1945).

McIntosh Reid (1919) based his correlations of the conglomerate of Black Bluff, Mt. Rowland and the Middlesex area on the relationship of the igneous rocks as stated by L. Hills in the Jukes-Darwin area. Reid's description however indicates that the West Coast Range Conglomerate Series is present in the Sheffield-Middlesex area.

The Mathinna Slates.

Some brief reference must be made to the rocks that outcrop around the Ben Lomond Plateau in the north-east of the State. These have usually been included in the Cambro-Ordovician, but have yielded very few fossils, and being to some extent isolated from the other rocks their stratigraphic correlation is in some measure of doubt.

A fairly well recognised and consistent series has been identified and named the Mathinna Slates (Twelvetrees 1911, 1916). Nye (1923) suggested a correlation with the Balfour and Bischoff Slates

and Sandstones and an Ordovician age, but gave no fossil evidence. McIntosh Reid (1925) suggested a correlation with the Dundas Slates and a similar age.

The most recent contribution to the age of these rocks is that of Dr. I. Cookson (1936). In 1934, F. Blake found some fossil plants at Warrentina, and this discovery led to the paper by Dr. Cookson. She compares the forms with *Hostimella* and with *Hedeia,* both of which occur in Victoria in beds of Upper Silurian and Lower Devonian age.

Plant remains have also been found on the main road from Launceston to Scottsdale, near Springfield (Thomas 1943), thus indicating that beds high in the Silurian or of Lower Devonian age are widespread in N.E. Tasmania. There is a strong possibility that rocks of a similar age are to be found much further to the south in the Fingal area, as Johnston records (1888, p. 59) *"Anodonta Gouldii* and Undetermined Plant Impressions" which made him include these beds in the Upper Devonian. At the same time it should be noted that he also included the Fingal Slates in the Upper Silurian (idem. p. 67). "No fossils have as yet been discovered, if we may except certain slates which are supposed to succeed them, from which the writer obtained a single species of *Anodonta,* closely resembling *A. Jukesii,* found in the Devonian rocks of Ireland."

Whether rocks of the same age extend to Lisle is not known. Thureau's *"Diplograptus nodusus"* was not accepted by T. S. Hall (1902), but Johnston found a sandstone which was replete with casts of a small species of *Orthis,* together with crinoidal stems. Further collections are necessary before the horizon of these beds can be determined.

The rocks of Beaconsfield may not belong to this group, although it appears reasonable to correlate the west Tamar rocks with those of the Lisle, Lefroy and Warrentina to the east of the Tamar. On the other hand, there has always been an assumption that the Beaconsfield limestones were to be correlated with those of Chudleigh and Mole Creek.

According to Nye (1928) conglomerates rest unconformably at Frankford, on the western side of the Tamar River, on older schists. "The conglomerates pass upwards conformably to sandstones, slates and the limestone of the Flowery Gully district. This series, many thousands of feet in thickness, should underlie the Mathinna Series. . ." This may be the clue to the relationship of the Silurian to the Ordovician in this part of the State.

The Ordovician Rocks

The extensive and economically important beds of massive limestone which occur in the Don-Melrose-Railton area, at Marrawa and at Gunn's Plains, Mole Creek and Chudleigh; at the Florentine River, Junee and the Great Bend of the Gordon; at the Weld River and at Ida Bay and New River are here referred to the same general horizon.

The Railton Melrose area has been mapped by Reid (1924). In discussing the age of these beds (1924, pp. 25-26), he recorded Ordovician fossils in the limestone and Silurian in the sandstone, although these were supposed to be interbedded, and he placed the Caroline

Creek sandstones in the Cambrian and the Railton limestones as succeeding these and of Ordovician age. (The Caroline Creek sandstones are now referred to the Ordovician, Kobayashi 1936).

At Caroline Creek (Haine's brick works) the sandstones, which yield *Tasmanocephalus,* are faulted against Permian rocks to the eastward, but elsewhere are covered by Pleistocene gravels, so that their relationship with the limestone is not observable. At Railton the succession appears to be in ascending order, conglomerate, Caroline Creek sandstone, and limestone observable at Blenkhorn's Quarry. Twelvetrees records collecting *"Ptychoparia stephensi"* (now *Tasmanocephalus stephensi*) at Blenkhorn's Quarry, from sandstones passing conformably below the limestone (Twelvetrees 1909, p. 8). He also records yellowish slates and sandstones in the Railton township, in which impressions of *Raphistoma* were found. These sandstones underlie the limestone of the Goliath Cement Company quarry and the limestones outcrop again in the valley of the Don on the Melrose railway, half a mile north of the quarries.

A. N. Lewis (1940) described the Junee series and correlated this with the rocks at Railton and Melrose. He maintained that the two corresponded sufficiently closely to justify their being grouped as one series which he named the Junee series. This extends to Tim Shea, where T. Stephens had discovered asaphid trilobites, and thence through to the Florentine and to the Great Bend of the Gordon. It also extends south of Mt. Mueller to the limestones at the head of the Weld. These limestones are interbedded with sandstones in which certain bands contain trilobites and other shelly fossils.

Limestones of the same age group include the beds at Gunn's Plains and Leven Valley (Twelvetrees 1909), and probably those under Quamby Bluff (Reid 1924).

On the information at present available it is impossible to definitely assign the beds at Mole Creek, Chudleigh, at Hastings, Ida Bay and at New River to this series, but in all probability they should be included in this group. The limestone at Beaconsfield (Ilfracombe) is still more difficult to place.

All these limestones are the "Primordial Calciferous Group" of R. M. Johnston (1888, p. 39-41). This group starts with conglomerates, which may be taken to mark the base of the Ordovician rocks. Both the conglomerates of this lower series and the West Coast Conglomerate Series were effected by the (?) epi-Devonian diastrophism, and the task of distinguishing between the influence of this younger and of the older one affecting only the lower groups has not yet been undertaken in the field.

Thick beds of quartzite and conglomerates are to be found everywhere that the Melrose-Junee series outcrops. Gould and Johnston recognised this conglomerate series in the Mersey Valley, and Johnston named it the "Magog Group," from the mountain of that name which is composed of this series. Later Twelvetrees identified the series on the Needles, and Lewis (1940) stated that it also caps Tim Shea, although Twelvetrees assigned the conglomerates there to a Permo-Carboniferous age. The conglomerates should thus on the grounds of priority in nomenclature be named the Magog Conglomerates.

Gould (1861) considered they succeeded the Melrose Limestone, and Johnston (1888, pp. 38-39) held a similar view of their relationship to the limestone at Chudleigh. Later investigations, however, reversed this order of succession. Thus Twelvetrees (1909, p. 9) identified this group at Gunn's Plains and in the Leven River Valley. He distinguished these conglomerates from the West Coast Range Conglomerates, and he also included in his Magog Group the Conglomerate at Penguin (Neptune Mine) Stowport, the Blythe Iron Mines and Emu River, and lists sections where they pass under the succeeding limestone.

McIntosh Reid (1924, p. 27), however, correlated with some doubt the Magog Conglomerates with the West Coast Range Conglomerates mainly on the identification of Rhynchonella in the overlying Tubicolar sandstones on the east of Badger Range and at Denny Gorge, Paloona Hill and Moina, but differentiated a lower conglomerate at Bott Gorge. Reid (1921, p. 17) also calls attention to the possibility that conglomerates of this series in the valleys of the Gordon and Florentine rivers (i.e., Denison Range-Thumbs-Tim Shea-Needles) have been confused with the West Coast Range Conglomerate Series. He had investigated the latter area in the course of his work on Osmiridium in Tasmania, and the view thus briefly expressed corresponds with that A. N. Lewis (1938) and of myself and Q. J. Henderson (1943).

It is probable that the conglomerates of the Magog Group vary rapidly both laterally and vertically into sandstones and quartzites. Without fossil evidence it thus becomes very difficult to separate these beds from lithologically similar ones occurring above the West Coast Range Conglomerates.

Along the North Coast, particularly at Ulverstone and Goat Island, and just west of Burnie, there are conglomerates and quartzites frequently highly contorted and often schistose in structure, which have been assigned to a pre-Cambrian age (Stephens 1874) on very little evidence, as similar rocks have been described in detail for the Smithton area (Nye, Finucane and Blake 1934), who maintain that they lie probably conformably below the Slate group.

A. N. Lewis (1923, 1938) has also described quartzites in the south-west of the State, and at Mt. Anne he shows that they overlie slates which he referred to the Dundas Series.

Lithological characters are thus of very little use in determining the age of these sandstones and quartzites.

The Cambrian (or "Lower Slate Group")

These "slates," which are very widespread and economically important, have been described from many localities. Several groups have been recognised, e.g., Dundas Slates, Balfour Slates and Bischoff Slates.

L. K. Ward first described these rocks at Dundas in 1909. He states that from the evidence supplied in the district he could not correlate them accurately with other series, but indicated that they are succeeded by a conglomerate series.

This description and the one by L. Hills covering the Read-Rosebery area to the north of the Dundas area (Hills 1915), must now be

read subject to the more recent view that the igneous suite are considerably later and entirely intrusive into the sedimentary group. There is a general opinion that the Dundas Slates underlie the West Coast Range Conglomerate Series. L. Hills (1915, p. 4) also records limestone interbedded with the slates at Hercules Mine, and Nye (1923) has given us the most complete description of them at Magnet (with analyses and petrographical commentaries). The latter distinguishes several divisions in the slate series there developed, namely a slate, a chert, a felspathic breccia and a micaceous breccia. Nye identified the Dundas slate series as defined by Ward, and also a new group which he termed the Bischoff series. He stated that outcrops were too infrequent to enable the different stages of the two series to be mapped, but regarded the Dundas series as being the older. Reid, working at the same time on the Mt. Bischoff portion of this field describes the Bischoff slates and records an unconformity between them and the underlying Dundas series (Reid 1923). Later, however, Reid identified the Bischoff slates at Dundas, but on lithology only, and considered them as there developed to be older than the Dundas series (Reid 1925).

The Dundas slates are usually described as purple to reddish, and occasionally grey to black, and appear to underlie the conglomerates and quartzites of the Magog Group. Twelvetrees (1908) described the relationship at the Humboldt Mine under the Needles; Ward at Dundas (1909); Twelvetrees at Gunn's Plains, Blythe River, Penguin, Alma (1909); Ward at Mt. Balfour (1911); Reid at Round Hill and Wilmot (1919); Nye at Adamsfield (1929); and A. N. Lewis at Pine Hill and Mt. Anne (1923 and 1940).

The downward succession of these old rocks is very obscure and has only been recorded in published work in Nye and Blake (1938). These authors refer to "pre-Dundas rocks" and assign to this group the Smithton quartzites, Farrel slates, Balfour slates, Arthur River slates and Hatfield Plains slates. One single fossil has been found in each of the last two "slate series," which have been assigned an Upper Cambrian age (Chapman 1925 and 1928) on this very slender evidence.

Hall's graptolites were found in the Dundas slates and assigned an Ordovician age (Hall 1902, Keble 1928), but doubt (Thomas 1945) has been cast on the identification of these forms as graptolites.

The discovery of "hydroid" remains at Dundas, together with some fragmentary remains of trilobites (Thomas and Henderson 1945), enables the Dundas Slates to be correlated with similar beds of Middle Cambrian age in Victoria. The black slate and the interbedded volcanic tuffs, ashes and agglomerates show a very close lithological resemblance to rocks of similar age in Victoria.

Although local names have been given to the slates as developed in the different localities, it seems that broadly they can be considered as a Lower Slate Series. There is no palaeontological or stratigraphical evidence which renders this impossible or even improbable.

Some of the subdivisions of this group may be usefully summarised as follows:—

Farrel Slates: This was set up by L. K. Ward in 1908, to include the dark slates and sandstones of the Mt. Farrel district, which appear to be older than the Silurian rocks of this district.

Dundas Series: (L. K. Ward 1909) is one of considerable thickness, composed of slates, generally red when weathered, but grey, green and black when unweathered, with fine grained breccias of volcanic material (basic felspar and augite) and cherts, tuffs, and basic volcanic rocks (Nye 1923). It has generally a faulted relationship to the younger rocks.

In the Rosebery district (K. J. Finucane 1932) dark slates and quartzites occur in addition to the above types, and in the Smithton district (Nye, Finucane and Blake) a limestone bed and thick dolomites are interbedded with rocks supposed to belong to this group.

Beneath the Dundas Series in the Smithton district (Nye, etc., 1934), dark slates and quartzites and fine conglomerates occur apparently conformably, and extend eastward to the white quartzites and dark slates of Sisters Hill, which had previously been referred to the Proterozoic.

Balfour Series: This series was described by L. K. Ward in 1910 (Bulletin No. 10) for the North-Western district. It comprises light coloured slates, quartzites and fine conglomerates intruded by granite and by basic dykes.

Bischoff Series: (Nye 1923) consists of alternating beds of slates and sandstone with subordinate conglomerates and breccias. No fossils have been found, but it is considered younger than the Dundas Series.

Rosebery Series: (K. J. Finucane 1932) includes the slates and quartzites of the Rosebery area, which are apparently stratigraphically beneath the Dundas Series.

The Relationship of the Cambrian to the Proterozoic

The Proterozoic Rocks have been described in some detail by W. H. Twelvetrees (Proc. A.A.A.Sc., 1907) and by L. K. Ward (Proc. Roy. Soc. Tas., 1909). The latter recognised two series from the evidence in the Surveyor Range where an upper series of quartzites unconformably overlie quartz and mica schists.

The basis of the separation of the Proterozoic from the Lower Palaeozoic has been the lithological character and their structural relationship with other series. Their schistose nature is more pronounced than that of the younger rocks, which according to most workers follow them unconformably. But very few areas showing this relationship have been recorded or examined in detail. At Frankford (Nye 1928), a contact of conglomerates with Pre-Cambrian schists can be seen, and he also states that a contact, not examined in detail, has been seen at De Witt Island off the South Coast.

In the Smithton area (Nye, Finucane and Blake, 1934), a group of slates was correlated with the Dundas Series (p. 53). Above this is a Dolomite, and beneath it a Chert Stage. Beneath the Chert Stage is a considerable thickness of rock divided into:—

2. Grey-green quartzite stage.
1. White quartzite stage.

It is considered that the grey-green quartzite stage conformably underlies the Dolomite stage (or where absent the chert substage), but there may be an unconformity between the grey-green quartzite and the underlying white quartzite stage, although these may form one stage.

These quartzites are correlated with those of the Sisters Hill (p. 25), of which they state: "This suite of rocks has been ascribed by Loftus Hills to the Upper Proterozoic, but they may represent transition beds between the Upper Proterozoic and Lower Palaeozoic or even be Lower Cambrian."

The separation of the Proterozoic rocks from the Lower Palaeozoic, as shown on the Geological Maps of Tasmania, cannot be regarded with confidence, for even on the road between Lake St. Clair and Queenstown there are fossiliferous beds which are Upper Ordovician or Lower Silurian, in the centre of a big area coloured as Proterozoic.

Summary and Conclusions

It is obvious from the foregoing that there is need for much detailed structural, palaeontological and stratigraphical research before the sequence of the Lower Palaeozoic rocks of Tasmania can be solved. Exhaustive collections are essential before the age of the various groups can be determined. Until this information is available, the major structural features cannot be studied, and there is no doubt that these are complex and of sufficient magnitude to have complicated the task of deciphering the stratigraphic succession.

The information Tasmania can yield concerning the development of the Tasman Geosyncline is most interesting. The succession—conglomerates, to sandstones or quartzites, and then limestones and shales—is well marked, not only in the Ordovician, but also in Silurian-Devonian times. The rapid alternations both vertically and laterally have however added to the difficulties of correlation.

There is probably a gradual passage from the Proterozoic to the Cambrian, resembling conditions as found in South Australia, if the Smithton area is considered as typical.

The volcanic activity of Cambrian times and the development of thick slates and shales following the cessation of this extrusive phase is matched by similar conditions in Victoria. In both States these slates are fossiliferous only at the lower horizons. In Victoria the Ordovician is mainly a shallow water facies, with relatively thin graptolitic shales representing deeper water conditions. In Tasmania the Ordovician commences with the conglomerates, then sandstones and limestones, and the comparable conditions are in Central Australia, rather than Victoria.

The Silurian-Devonian is initiated in Western Tasmania by the West Coast Range Conglomerates, which are succeeded by sandstones, limestones, and shales, all showing the characteristics indicative of rapidly alternating conditions of sedimentation. In Victoria there is a well-defined lithological break between the Upper Ordovician and Silurian, and thin interbedded conglomerates are only sporadically developed in the lower Silurian (Keilorian) rocks. Higher in the sequence lenticular limestones and conglomerates approximately mark the boundary between Silurian and Devonian. Conditions in Tas-

mania indicate more fluctuating depths than in Victoria, but the deeper water facies as developed in the Walhalla Synclinorium is matched by the lithologically similar Mathinna "series"; both having shallower water beds with plant remains.

Without more detailed knowledge of Tasmanian stratigraphy and structure, it is difficult to draw closer comparisons. It is thought, however, that the identification of three major groups will be of help, but the following summary merely serves to show the gaps in our knowledge:—

1. The relationship of the Cambrian to the Proterozoic is not known with certainty.
2. There is a thick development of slates frequently associated with basic volcanic activity, which can be considered as of Cambrian age. (It is likely, however, that there is also a later development of basic rocks comparable with those at Waratah Bay in Victoria, i.e., post Upper Silurian at least.)
3. The Ordovician is initiated, wherever studied in detail, by conglomerates succeeded by beds containing the Tasmanocephalus fauna and by limestones with large cephalopods. The conglomerates must be low in the Ordovician (Tremadocian), but the age of the upper beds of this group is not known. If the limestones on the Mersey River and the Queenstown flux quarry are Upper Ordovician, the age of the succeeding conglomerates in all probability is Silurian. The King River Series are probably of the same general age as these limestones, which, however, according to Dr. D. Hill, may also doubtfully be Silurian.
4. The exact age of the West Coast Range Conglomerates is not known. They overlie, unconformably, beds probably of Upper Ordovician age (or more doubtfully Silurian age) and are succeeded conformably by the Gordon River Limestone Series of undoubted Silurian age. Higher still in the sequence are the Eldon Beds and the Pleurodictyum-bearing beds at Zeehan, which may be Lower Devonian in age, and may thus be correlated with the Mathinna Slates.

This contribution is an attempt to review the literature, and although it perhaps errs in over-simplifying the Lower Palaeozoic Record, it also indicates some of the problems yet to be solved. Much of the work of the Tasmanian Geological Survey remains in manuscript form, a state of affairs that should be remedied as it is difficult to gain access to these papers. It is thus possible that some of this later work has, unintentionally, been omitted from this discussion.

References

CHAPMAN, F., 1919. On the Occurrence of Tetradium in the Gordon River Limestones. *Geol. Surv. Tas. Record* 5, 1919.

———, 1925. On a supposed Phyllocarid from the Older Palaeozoic of Tasmania. *Paps. Roy. Soc. Tas.* 1925, p. 79.

———, 1928. On some remarkable annelid remains from Arthur River, N.W. Tasmania. *Paps. Roy. Soc. Tas.* 1928, p. 1

CONDOR, H., 1918. The Tin Field of North Dundas. *Geol. Surv. Tas. Bull.* 26, 1918.